Determining Speed

Accident investigators use skidmarks, together with other factors, to estimate the speed of a vehicle involved in an accident. **Skidmarks indicate the vehicle's MINIMUM TRAVELING SPEED,** not the actual traveling speed. It will show what speed a vehicle had to travel, at the very least, to leave that t ype of skidmarks. If it is found that this speed is in excess of the posted speed limit, then speed could be a factor in the accident. If not, it will indicate that the investigator must look for other evidence.

This chapter explains how to determine speed from the length of skidmarks. There are two other factors that affect the skidmark length in addition to speed **—coefficient of friction and grade or slope.**

Coefficient of Friction

It is necessary to determine the coefficient of friction to establish how drag or resistance of a roadway affects a vehicle attempting to stop. This will vary from roadway to roadway since each is different in design, construction material, age and condition. Slippery pavement offers less drag so the stopping distance is greater. Rough pavement creates more drag and the stopping distance is less.

The following steps are used to find the coefficient of friction:

How to Determine the Coefficient of Friction

Example Problem: You have made a test skid in a vehicle travelling 30 mph. The skidmark measurements are as follows:

Left Front = 60 feet
Right Front = 62 feet
Left Rear = 57 feet
Right Rear = 59 feet.

Step 1 Add the lengths together.
60 + 62 + 57 + 59 = 238

Step 2 Divide by 4 to find the average skidding distance.
238 divided by 4 = 59.5

Step 3 Square the speed.
30 x 30 = 900

Step 4 Divide 900 by 59.5 (distance or d).
900 divided by 59.5 = 15.13

Step 5 Multiply this by 0.033 (a constant).
15.13 x 0.033 = .4992 or .50

On a road surface in the general area of an accident, drive a vehicle like the one involved in the accident, if possible, or the patrol vehicle at what you believe may have been the speed of the vehicle that made the marks. It is important to use the same pavement in the same condition, but less important to use the same vehicle.

Drive at the estimated accident speed unless it would be unsafe. A good test speed is the speed limit if it is 35 mph (55 km/h) or less. Then, if accident skids are longer than speed-limit test skids, there is direct proof that the vehicle's speed was greater than the speed limit.

Hold the speed constant as the vehicle reaches the right place on the road; note the speed shown on the speedometer; hold the steering wheel steady; put on the brake very hard and very quickly; and hold it until the vehicle stops.

Then measure the length of each mark. Repeat the test. If the second test gives approximately the same stopping distance as the first (within 10%) consider the test adequate. If it does not, repeat the test until consistent results are obtained.

Add the four skidmarks together and divide by four. The result is the average skidmark length. The coefficient of friction is then determined by using the Speed Nomograph or with a mathematical equation:

- **Speed Nomograph—** Using a ruler, connect the distance measured and the speed of travel. Then read the number at which the ruler crosses the skid resistance line. This is the coefficient of friction.
- **Equation**— To find the coefficient of friction, square the speed and divide your answer by 30 times the distance:

$$F = \frac{5^2}{30d}$$

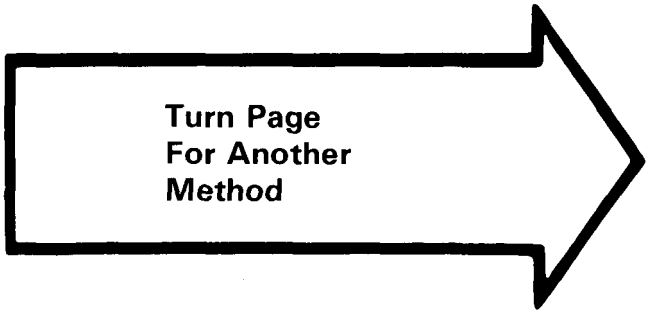
How to Determine Grade With the Speed Nomograph

Step 1—Place the speed nomograph on a clipboard. Drill a hole at the center top of the clipboard and the nomograph. This is the pivot hole. Place a pencil with a weighted string through this hole.

Step 2—Place the clipboard's bottom edge on a perfectly horizontal surface and let the string hang free. Adjust the nomograph until the zero mark of the grade scale is aligned directly under the string. Then firmly fasten the nomograph to the clipboard with tape.

Step 3—Readings are now made at each end of a skidmark and in the center of the skidmark. To do this the clipboard's bottom edge is placed against the road surface. A grade scale reading is then made. At least three readings must be made.

Step 4—Average the readings. This gives the average grade and this is the number to use in computing estimated speed.



How To Find Grade

Grade or slope refers to the steepness of a hill and is important in estimating speed from skidmarks. It is the number of feet the roadway rises for each foot of level distance along the road. The resulting number is less than .010 except for very steep hills. If you are measuring the grade for its uphill effect, it is termed a positive grade and a plus sign (+) is placed in front of the number. If the downhill effect is measured, it is termed a negative effect and a minus sign (-) is placed in front of the number.

Grade must be measured when a test skid at the accident location cannot be made or the coefficient of friction is to be found using the math equation. Grade can be measured with the speed nomograph or with a level.

How To Find Other Factors

The preceding information has been concerned with finding minimum speed from skidmarks on a straight surface. If, however, the accident occurs on a curve and the curve is banked, other computations must be made to determine speed. Consideration may have to be given to superelevation (bank) or curve, whether a curve is sharp or long and sweeping and the critical speed and skidmarks on two different types of pavement.

How to Determine Grade Using a Level

Step 1—Obtain a carpenter's or mason's level and a ruler or tape measure. The longer the level, the more accurate the measurements will be.

Step 2—Lay the level on the roadway surface with one end uphill and one end downhill.

Step 3—Raise the downhill end until the bubble centers, and hold it in that position. Then measure the distance from the roadway to the bottom edge of the level.

Step 4—Divide this distance by the length of the level. For example, if the distance is one inch, and the level is 36 inches long, 1 divided by 36 equals .0277. This means the grade is approximately 3 percent.

Superelevation (Bank)

Superelevation is the grade across the roadway at a right angle to the centerline. It is measured from the inside edge of a curve to the outside edge. It is necessary that it be measured in cases where a vehicle slides or runs off a roadway curve. It is measured preferably with a template or level. It is usually 0.10 (10%) or less. The measurement should be made where the vehicle went off the roadway, or in the middle of the curve.

Radius of a Curve

The radius of a curve must be measured so the critical speed of a curve can be determined. **Critical speed is the maximum speed a vehicle can negotiate a curve without being forced off the roadway by centrifugal force.** The method used to find the radius of a curve depends on whether it is sharp or long and sweeping.

Sharp Curves

Sharp curves are those which have a radius of less than 1500 feet (460 meters). Steps for finding the radius are as follows:

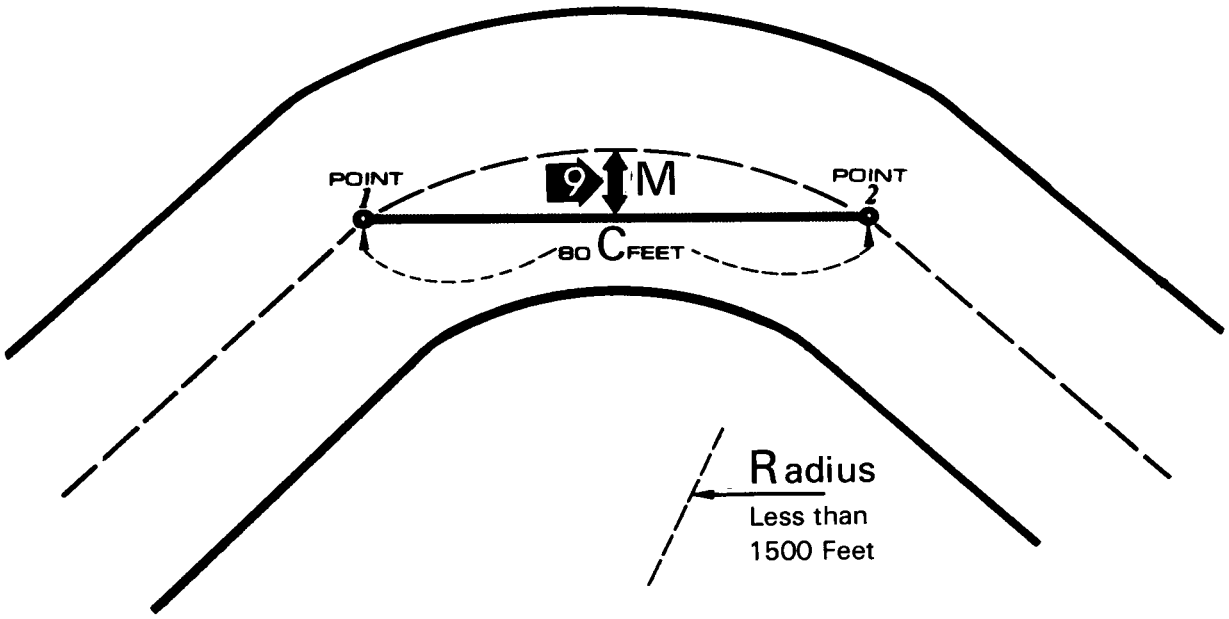
1— Using a measuring tape, find two points on the center line 50 to 100 feet (15-30 meters) apart. Mark these points and leave the tape on the ground flat and straight. This is called the "Chord" (C in the figure at right).

2— Divide this length in half to locate the center and mark this point.

3— From this middle point, measure the shortest distance to the center line. If there isn't a center line, measure to the outside edge of the roadway. This distance is the "Middle Ordinate" (M in the figure).

4— Use the following formula to find the radius:

$$R = \frac{C^2}{8M} + \frac{M}{2}$$



$$R = \frac{C^2}{8M} + \frac{M}{2}$$

$$R = \frac{80 \times 80}{8 \times 9} + \frac{9}{2}$$

$$R = \frac{6400}{72} + \frac{9}{2}$$

$$R = 88.88 + 4.5$$

$$R = 93.38$$

$$R = 93^{5}*$$

Legend

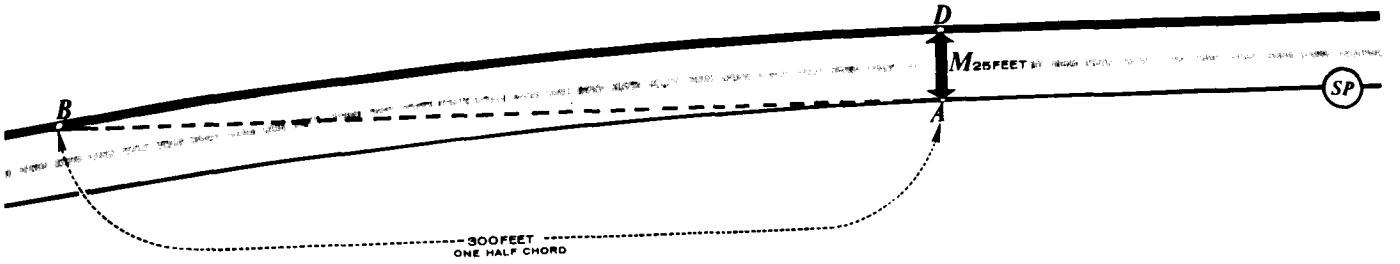
M Middle Ordinate

9 Length of M (9 Feet)

C Chord

$93^{5}*$ = 93 Feet 5 Inches

Measuring Radius of a Sharp Curve



RADIUS
GREATER THAN
1500 FEET

$$R = \frac{C^2}{8M} + \frac{M}{2}$$

$M = 25$

$C = 2 \times 300 = 600$

LEGEND

A	THE BEGINNING OF THE CURVE
B	EXTENSION OF SIGHTING LINE INTERSECTING OUTER EDGE OF ROADWAY
A–D	WIDTH OF ROAD AT A
SP	SIGHTING POINT ON THE STRAIGHT EDGE OF ROAD
C	CHORD

$$R = \frac{600 \times 600}{8 \times 25} + \frac{25}{2} = \frac{360000}{200} + \frac{25}{2} = 1800 + 12.5 = 1812.5$$

$R = 1812.5 = 1812\frac{6}{}$ = 1812 FEET 6 INCHES

Measuring Radius of a Long Sweeping Curve

Long Sweeping Curves

There are curves with a radius of more than 1500 feet (460 meters). Steps for finding the radius are as follows:

1— On the inside portion of the roadway, locate the beginning.of the curve as closely as possible. Do this by sighting along the straight portion with a straight edge. Mark this point (A in the figure above).

2— From this point, sight across the roadway with a straight edge, as though the road continued straight. Mark the point on the other side of the roadway (B in the figure).

3— Measure the road width at point A and mark it. (D in the figure). This is the middle ordinate. (M in the formula).

4— Measure the distance between points A and B and multiply by 2. This is the Chord.

5— Then use the following formula to find the radius:

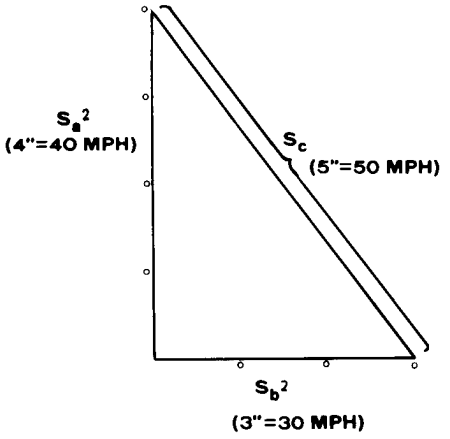
How To Find Speed

Speed information is determined from skidmarks and will only indicate the minimum speed which the vehicle had to be traveling to produce that length of skidmarks. The following explanation will include finding speed from skidmarks left on one-surface type roadways and on two-surface type roadways.

One-Surface Types

Step 1— Determine the coefficient of friction (see page 90).

Step **2—** Determine grade. Add the grade factor to the coefficient of friction if it has an uphill effect. Subtract it if it has a downhill effect.



Calculating Combined Speed With a Pythagorean Triangle

Step 3— Determine the average skidmark length.

Step 4— Using the speed nomograph (see figure on page 96) and a straight edge, align the coefficient of friction (skid resistance) with the average skidmark length (distance). Then read the speed column to find the speed.

Step 5— If a speed nomograph is not available, the following formula can be used:

$S=5.5\ d\ (F\pm f)$

Two-Surface Types

If an accident vehicle skids over two types of road surfaces individual measurements and calculations will have to be made on each surface type. This involves measuring separately the distances of skidmarks on each surface, and two test skids to determine separate coefficients of friction for each surface. Grade will usually be the same for both surf aces. Minimum speeds are then determined for each surface using the method outlined in the preceding paragraph. The following formula is then used:

$$Sc = S_1^{\ 2} + S_2^{\ 2}$$

Sc is the combined speed.
$S_1^{\ 2}$ is the speed on surface one squared.
$S_2^{\ 2}$ is the speed on surface two squared.

The Pythagorean right triangle can also be used to find combined speed. Scale the separate speeds. For example, have 1 inch equal 10 mph. On the corner edge of a piece of paper, mark the scaled speed on one edge, and the other speed on the other edge. Then draw the hypotenuse and measure it. This length is scaled to speed.

How To Find Critical Speed Of a Curve

Critical speed is the maximum speed a vehicle may negotiate a curve without being forced off the road by centrifugal force. To find critical speed of a curve, the radius of the curve, superelevation and coefficient of friction must first be determined. The easiest way to find critical speed is to use the speed nomograph, taking the following steps:

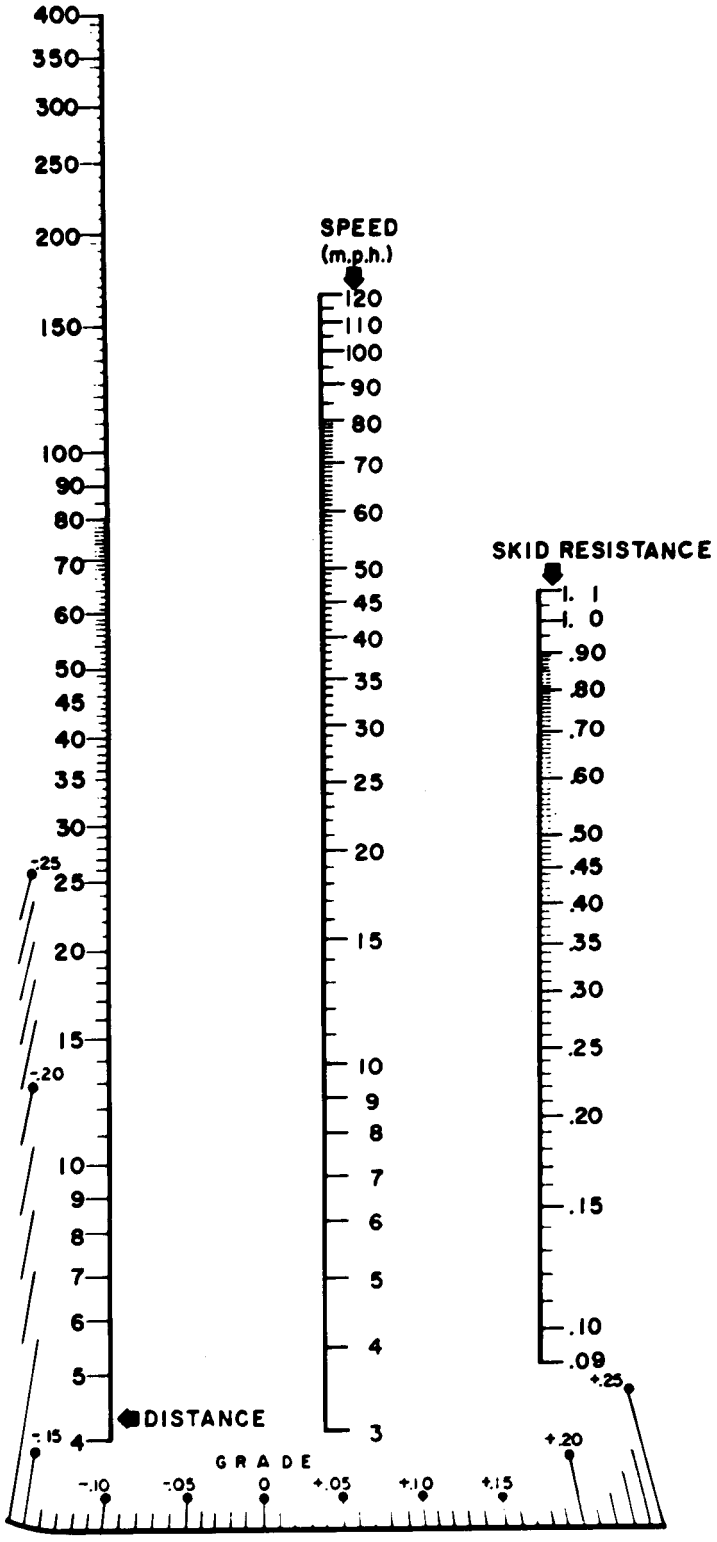
1— Divide the radius by 2. Mark the result on the Distance scale.

2— Add the coefficient of friction and the superelevation together. Mark this result on the Skid Resistance scale of the speed nomograph.

3— Connect both marks with a straight edge and read the Speed scale. This is the critical speed. The formula is:

S = 3.87 RF

Speed Nomograph



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Speed Nomograph